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Bulletin No. 69

Oil Series No. 2

University of Arizona Bulletin

Prospecting for Petroleum

BY
M. A. ALLEN



Entered as second class matter November 23, 1915, at the postoffice at Tucson, Arizona, under the Act of August 24, 1912. Issued weekly, September to May.

PUBLISHED BY THE

University of Arizona Bureau of Mines

CHARLES F. WILLIS, *Director*

TUCSON, ARIZONA

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University of Arizona Bulletin

OIL SERIES No. 2

NOVEMBER 20, 1917

BULLETIN II.

PROSPECTING FOR PETROLEUM

INTRODUCTORY

The lack of knowledge, among the many prospectors of the State of Arizona, of what constitutes a deposit of petroleum and the indications of its presence, has prompted the writing and production of this bulletin by the Arizona State Bureau of Mines.

It does not attempt to be a complete treatise on the subject of petroleum prospecting, but it is hoped that the contents will be of material assistance to the people and prospectors of the State.

This bulletin is the second of the following series:

Oil and Its Geology.

Prospecting for Oil.

Drilling for Oil.

Laws Pertaining to Oil.

There is a lack of oil fields in Arizona, but there is every reason to believe that oil occurs. It may remain, however, for it to be discovered, as most fields have been, by chance.

HISTORY

The oil wells of the Appalachian field were first discovered by seepages. Near these seepages shafts were first sunk, many of these shafts being sunk in the 17th and 18th centuries by the early settlers, the product being used for medicinal purposes.

Oil in any appreciable quantity was first obtained in the United States from the brine of the brine wells in the Kanawha district, Pennsylvania. This oil was collected and sold for lubricating purposes and other uses.

When in 1820 better methods were devised for drilling to depths of 1000 feet or more, larger amounts of oil rose with the brine.

In 1859 serious public attention was given to petroleum as a remunerative enterprise, when Col. Drake began prospecting for oil. He commenced by sinking a shaft, but met with such trouble that he resorted to wells similar to those sunk for artesian water. His first

well struck oil, and upon it followed the excitement which led to the development of the great Appalachian oil field. This field extends throughout the states of New York, Pennsylvania, Eastern Ohio, West Virginia, Kentucky, and Tennessee. The oil from these fields is characterized by its richness in paraffin, freedom from sulphur, and high yield of spirit and illuminating oil.

Russia has a petroleum history similar to that of the United States. Pits for oil have been known there since the time of the ancients. The gases from such deposits, when lighted, were the shrines of the fire-worshippers from Persia. Marco Polo describes these deposits.

At the present time leases are given for the purpose of sinking shallow pits for the accumulation and collection of this surface oil.

In 1871 the first well was drilled in the Baku fields of Russia, and since then that country has been a large producer of petroleum.

The oil fields of Canada have much the same history. Indications of oil on the surface were observed by the earliest settlers. Land and water in these vicinities were condemned because of the nuisance. However, in 1857, better informed men were interested. A man named Shaw dug a well, as for water, and after a few days' digging struck a considerable flow of oil that filled the well, overflowed its rim, and ran into the river. Then followed the usual excitement and prodigious waste.

The oil of Galicia has been known for a very long time, it having been collected in early times and used as a balsam or cure for rheumatism and other ailments.

Oil was first exploited there by sinking shafts or wells, and later by boring. The wells of East Galicia gradually became non-productive. Since being drilled to greater depths (3000-4000 feet) these fields have again become important producers.

In the Illinois oil fields the geologists were confident of the presence of oil some thirty years before extensive prospecting was done. The first commercial wells of Illinois were brought in near Litchfield, fifty miles northeast of St. Louis, where, when drilling for coal in 1882, gas was discovered, which supplied the town for several years. Later some oil wells were drilled that produced lubricating oil.

In 1887 gas was discovered, in drilling for water, at Sparta, forty miles southeast of St. Louis. In 1906 several oil wells were brought in northeast of the old gas wells.

In 1890, in drilling for water, gas was discovered near Pittsfield in Pike County. On some of the showings of these gas wells, people were sufficiently interested to prospect for oil, but met with failure from various causes, such as drowning by water, dry wells, etc. Per-

sistence, however, led to a good well being brought in. From then on the fields were rapidly developed and extended.

The history of the Furbero field of Mexico is similar to that of other fields. The seepages of this field were early exploited by the natives, their old workings consisting of a walled-up shaft which was found by the earliest known white explorer.

In 1868, Dr. Aubrey discovered large seepages and he floated a company in Mexico City for the purpose of exploiting these deposits.

Machinery was brought into the region and a three-inch bore hole was put down near the seepages to a depth of 125 feet. No production resulting from this, a tunnel was driven for 50 feet in the side of the hill near the old Indian workings. A moderate supply of oil was obtained (4-5 bbls.) but the prospect was soon abandoned.

In 1883, by the enactment of a petroleum law, the land passed out of Dr. Aubrey's hands. In 1901 the Mexican Petroleum and Liquid Fuel Company was formed and took over these lands. During the years 1901-1902 operations were pushed and twenty-four wells were drilled to depths of over 1500 feet. The operations from a commercial standpoint were unsuccessful and the field abandoned.

In 1903 the "Oil Fields of Mexico" Company was organized and took over this property. They commenced drilling and in 1907 brought in their first commercial well. From that dates the development of the Mexican fields.

During the years 1880-1883 several shallow wells were drilled in other fields in Mexico, but were failures.

The Caddo oil and gas field of Louisiana was opened by following the numerous surface gas seepages in places in northwestern Louisiana. The Shreveport Ice and Refrigerating Company had been lighted by natural gas for years, the well supplying their gas being discovered by accident in drilling for water.

The first ten years of testing in the field did not meet with any great success.

In 1905 a gas well was struck and the gas pressure blew out the derrick, the roar of the gas being heard for miles. Upon this discovery followed the usual feverish development and extension of the field.

The famous pitch lake of Trinidad has been world-known for centuries. This pitch is a petroleum residue. The relation it bears to petroleum fields has not been conjectured till recently, but work done by the Geological Survey of Trinidad points to very favorable results.

The oil-bearing belt of Peru extends several hundred miles in an almost arid region similar to Arizona. Many of the tracts of Persia and Mesopotamia on which oil indications occur are very similar to

the Utah, New Mexico, and Arizona regions, in climate and physical geography.

Many of the productive fields of today have been the result of so-called "wildcatting." A small indication of oil was seen and upon this was based the formation of companies and the raising of money for drilling. Some have been successes, but there have been many more failures.

PROPERTIES OF PETROLEUM

Petroleum is an oily fluid of viscous nature, and, according to its color, more or less transparent. The color will range from a straw-yellow, through shades of red-brown, to brown to black and sometimes greenish.

The odor may be agreeable and slight, or strong. A disagreeable odor is mostly due to the presence of sulphur impurities.

Some oils solidify on exposure to the atmosphere, due to the volatilization of the lighter constituents, leaving only the paraffin or asphalt contents.

PROSPECTING FOR PETROLEUM

Man has naturally been attracted to those places where oil has indicated its presence by its many surface showings. These indications have resulted in the exploitation of the oil-bearing strata, though many of our famous fields have been discovered by chance in drilling for some other material.

In searching for oil deposits it is well to bear in mind that oil occurs in sedimentary rocks and practically never in igneous rocks. The Mexican oil fields occur in close association with igneous rocks, but the sedimentary are found to be the actual containers.

Oil is almost always associated with some sort of folded or arched structure, such as domes, anticlines, monoclines, terraces, and, in exceptional cases, synclines.

The presence of petroleum in the rocks of a district is not always indicated by any outward signs which would give the least clue to the casual observer.

In searching for oil it is best to locate the visible indications, and then inquire into the further possibilities of its presence.

The visible indications of petroleum can be divided into two classes:

1. Surface.
2. Underground or Borings.

SURFACE INDICATIONS

The following is a list of the more important surface indications of oil:

- a. Vegetation;
- b. Seepages of oil;
- c. Asphalt deposits;
- d. Emanations of gas;
- e. Outcrops of bituminous matter;
- f. Veins of bitumen;
- g. Relation of sulphur, salt, and gypsum to oil.

a. *Vegetation.* The petroleum-bearing regions of the world vary greatly in their physical characteristics. Oil not infrequently exerts a very marked influence on the vegetation of the petroleum-bearing region; although its effect on vegetation is more or less controlled by the climatic conditions of the country. In a region where rain is scarce and the country very arid the effect is very pronounced, the petroleum and its accompanying compounds completely laying barren the whole surrounding country. The intense vegetation in tropical countries flourishes on land soaked with oil and pitch. Examples of this are the oil fields of Borneo, Sumatra, East and Central America, and Trinidad. Barren wastes characterize the fields of Persia, Egypt, Algiers, and Peru. The Arizona fields would resemble these.

b. *Seepages of Oil.* Wherever petroleum-bearing rocks come to the surface there are usually oil seepages and the oxidized products of petroleum. The seeping oil, when exposed to the atmosphere, loses its more volatile constituents, leaving behind a solid or pasty pitch.

The character of the "showing" depends on such local conditions as climate, topography and quantity of oil. In low, flat country the rain has not the power of erosion as in hilly country and does not wash away the seepages as readily. The soil then becomes coated with a black, solid, viscous covering, as the lighter petroleum constituents evaporate.

In hot, dry regions dust will accumulate in this sticky pitch and produce a hard, brownish material.

Where the oil seeps from the sides of the hills, pitch masses accumulate in the valleys, but these traces may be washed away by rain.

These pitch accumulations often contain foreign matter which has become imbedded in them, such as animal remains, insects, vegetable remains, etc.

These seepages should be looked for in low ground, beds of streams,

at the base of hills, and where there are indications of strata-folding at or near the anticlinal crest.

Erosion will sometimes cause all indications of oil to be lost, but where the formation crosses a valley a seepage may be noticed. In such places films of oil of beautiful irridescence may be seen on the surface of water.

Their odor will at once distinguish these films from those of hydroxide of iron, which is the result of decomposing bicarbonate of iron. These latter are easily mistaken for evidences of petroleum.

If the seepages are large the oil may be seen to trickle out, the color varying from brown or greenish to black.

The petroleum will not exude from all along the petroleum-bearing formation as the continual accumulation of pitch seals the surface pores of the rock. The greater part of the outcrop may have to be trenched from inches to feet before showing any evidence of being petroliferous.

The kind of oil coming from the seepages will influence the size and nature of the showing.

Oils with a paraffin base usually make smaller and less striking seepages than asphaltic oils. This is due to the nature of the remaining oil-matter after the more volatile compounds have evaporated. Paraffin oils evaporate more readily, leaving behind little reddish-brown flakes of paraffin or solid paraffin resembling vaseline.

The asphaltic oil remains liquid longer and on evaporation yields a black asphaltic mass.

Seepages which have gone on for centuries give rise to deposits of asphalt, which are mined as in Russia, California, Trinidad and Mexico.

Seeping oil may be filtered or fractionated if it passes through clays and may have the appearance of the very lightest kind of oil, as a straw-yellow kerosene.

If oil-bearing formations are thickly covered with other strata and alluvium, the seepages may not occur, especially where the formations are flat and little eroded. However, seepages may occur a considerable distance from the source as, for instance, at the point where igneous rocks or mountain ranges break through.

Mineral and vegetable stains have been mistaken for oil seepages. Oil sands which have been discolored by sulphur stains will appear almost white.

c. *Asphalt Deposits.* Asphaltic base oils, when they occur in sufficient quantity and the conditions are favorable for the accumula-

tion and evaporation of the seepages, give rise to large deposits of asphalt.

The deposits of asphalt resulting from the accumulation of the residue of asphalt base oils have reached enormous sizes in Trinidad. There was much speculation as to its origin, but it has now been definitely determined, as asphaltic oil deposits are known to exist within the island.

The lake could easily have been formed by the bubbling of vapors which disintegrated the rock, this disintegrated rock being carried away by the water and oil. Finally a basin was produced in which the asphalt accumulated. Examples of just such crater-like formations, produced by gas disintegrating the limestone, have been seen in Western Texas by the writer.

In the forests of Trinidad the outcrop of an asphaltic oil sand is usually marked by the presence of stunted vegetation.

An outcrop exudation is often valuable in indicating the dip of the strata. As the outcrop becomes clogged by the asphalt, the liquid breaks out again in the direction of the dip slope.

It is often claimed that asphaltic deposits are indications of depleted oil sands. This may be true in some cases, but when an outcrop still exudes oil and shows asphalt it is a valuable indication, as has been proved in California, Mexico and Trinidad.

Asphalt deposits occur in Venezuela. In Texas discs of solid bitumen are thrown up on the shore by the sea, giving evidences of marine seepages.

d. *Gas Emanations.* Oil seepages are almost invariably accompanied by gas, but oil does not always accompany gas emanations.

These gas emanations may be one or all of the following:

1. Inflammable gas:
 - a. Natural petroleum gas;
 - b. Marsh gas, due to causes other than petroleum.
 - c. Hydrogen sulphide.
2. Non-inflammable gas:
 - a. Sulphur dioxide;
 - b. Carbon dioxide;
 - c. Nitrogen.

The above gas emanations are usually accompanied by many physical phenomena.

Although the presence of natural inflammable gas is not indicative of the presence of petroleum, its presence together with other evidence cannot be overlooked.

Although natural gas contains large quantities of marsh gas, marsh gas is usually the result of decomposing vegetable matter of swamps and may come from other bituminous deposits, as coal beds, etc.

Natural gas can usually be distinguished from marsh gas by its paraffin or petroliferous odor.

On applying a light to the escaping gas it will take fire and continue to burn with a slightly luminous semi-transparent flame if the supply is continuous.

The escape of gas cannot be easily detected in dry, barren regions, but it is usually recognized by the odor of the gas which will collect in sheltered gullies or by bubbles in pools of water or beds of streams.

One or all of the non-inflammable gases general accompany natural gas emanations, and by the distinctive odor of hydrogen sulphide and sulphide dioxide the odor of the petroleum gas will be entirely masked.

Gas will continually escape from crevices and faults coming from considerable depths. Again the emanation may be at the top of an inclined oil strata or from the fractured crest of an anticline. The gas may escape in minute quantities over a large area or may come from one place. In some petroleum regions the gas will burst forth at distant intervals of time, the place of emanation showing no signs of petroleum or gas.

Gas emanations frequently occur in lakes, rivers and seas. Localities such as these are in Louisiana, off the coasts of Texas, Burma, Borneo and Trinidad.

When gas passes to the surface through clay or argillaceous material, the emanations are accompanied by mud volcanoes. The clay and water form a puddled mass agitated by the bubbling gas. The escaping gas blows the puddled clay into large bubbles which burst sometimes with explosive violence. The continual bursting of these clay bubbles form mud cones, resembling the crater of a volcano. These cones and mud volcanoes in many regions cover large areas.

The gases which accompany natural petroleum gas are carbon dioxide and nitrogen, which have no odor, and hydrogen sulphide and sulphur dioxide, which are characterized by their disagreeable odors.

Carbon dioxide is a non-odorous, non-inflammable and invisible gas. It is heavy and will collect in low lying places.

Nitrogen is a constituent of the air and therefore cannot be readily detected when escaping.

Sulphur dioxide is easily detected by its pungent odor and its stinging effect on the nostrils. It is often present in oil-bearing regions. This gas is present in the Texas and California oil fields. The gases

of Spindle Top, Texas, were extremely poisonous because of the sulphur gases, and resulted in many deaths.

Sometimes the escape of these gases leads to the precipitation of yellow sulphur in the crevices and on the surface where the gases occur. The sulphur is the result of the chemical action between sulphur dioxide, hydrogen sulphide and water.

Hydrogen sulphide can be detected in the vicinity of oil by its very disagreeable odor. These gases will collect in depressions and form acids in water, which results in the death of animals attempting to drink such water.

Many oil wells yield an abundance of both hydrogen sulphide and sulphur dioxide. Hot sulphurous waters are also occasionally met with in oil fields.

These latter indications are often present in volcanic regions also, and must not be confused.

The hydrogen sulphide and sulphur dioxide gases, when accompanied by oil, are from oil-bearing strata and are supposed to come from the sulphur contents of the oil or its asphaltic remains. Some oils are high in free and organic sulphur compounds which detract from the value of the oil.

c. *Outcrops of Bituminous Matter.* Rocks containing bituminous matter are widely scattered over the earth. Many of these bitumen-bearing rocks are the outcrops of oil-bearing strata from which the lighter products of the oil have been lost.

When seepages, gas emanations or exudations of asphalt are not present, oil-bearing strata can be recognized by its outcrop. These oil rocks, on close examination, will be noticed to contain a product which resembles tar or asphalt and will give the rock, when a sandstone, a tough and plastic property.

When the oil is of asphaltic base this outcrop is more marked than in the case of paraffin base oil, because the residue of the latter cannot withstand weathering as well as the former.

When the weathering is severe all the traces of oil will be washed away, and the fact of the rock being an oil rock can only be detected by examining the rock for sulphur and by breaking into the outcrop.

When paraffin base oils are suspected of being present it is necessary to break open the harder and more compact parts of the bed, as the least porous rock will withstand the greatest weathering. Sometimes the freshly fractured rock will smell of vaseline or petroleum.

Where the oil rock is a limestone the same indications as above will exist.

Metallic oxides and sulphides, iron or manganese compounds may in some cases resemble oil strata in color, but if the rock is crushed and treated with benzine there can be no mistake made.

Many of the bituminous sandstones, shales and limestones are excellent road material and are mined extensively. These rocks, when containing a large percentage of bitumen, are treated for the bituminous matter.

f. *Native Bitumens.* These bitumens can be divided into two classes:

1. Those resulting from oils of paraffin base as Ozokerite.
2. Those resulting from oils of asphaltic base, as Grahamite, Wurtzelite, Albertite, etc.

The bitumens are quite distinct from the oxidized seepages of petroleum (pitch and asphalt) which are always contaminated with earthy matter.

Bitumens occur in veins, faults or fissures in strata overlying the oil-bearing rocks, and are the result of certain actions on escaping petroleum, causing the bitumen to be deposited in the fissures. Their presence in a district may generally be regarded as an indication of the presence of petroleum, although it may be at great depth.

These bituminous minerals vary from hard, brittle, glistening substances to soft, dull masses. They are usually free from earthy impurities. The commercial value of the bitumen depends on the purity, melting point, elasticity, and insulating properties, and according to these qualities vary in value from \$15 to \$100 per ton.

Ozokerite, which is the most valuable bitumen, varies in color from white to black, the other bitumens being invariably brown to black, and all having a brilliant lustre.

Relation of Sulphur, Salt, and Gypsum to Oil. The relations of sulphur, salt, and gypsum to many of the oil fields of the world is very close. Almost all the waters found in oil formations are saline. The early brine wells of America, before oil was discovered, yielded small quantities of oil.

Thick beds of salt were met with in drilling for oil in Texas, Roumania, and Galicia.

Outcrops of rock accompanying the petroleum series are often coated with salt in arid regions. This salt results from the slow evaporation of the saline water coming from below.

The water coming from oil wells is almost always saline. This water, in some districts, is raised in large quantities.

Sulphur is found in some oils to a very large extent. In Texas and

Louisiana sulphur deposits of large size occur in the petroleum-bearing formations.

The action of hydrogen sulphide and sulphur dioxide gases on limestone is marked because of the conversion of the limestone to gypsum, a hydrous sulphate of calcium. Gypsum is frequently found in close proximity to oil-bearing rocks.

A prospector is frequently assisted in his search by native stories of the occurrences of seepages, gas emanations, bituminous deposits, and the like. Many of the names for localities, towns, rivers, streams or mountains may be the native word for petroleum, pitch, asphalt, etc., for example:

Chapapote, Mexican for petroleum residue and oil.

Brea, Spanish for mineral wax.

Cougas, the former name for the Furbero oil field. *Cougas* is the native word for black wax or oil.

(2) UNDERGROUND OR BORE HOLES

The evidence of bore holes is often very valuable in that it will indicate the advisability of continuing drilling or it will indicate whether the petroleum-bearing beds in that locality are thick or thin. If the geology of the district is known the bore hole will indicate when the oil-bearing strata is being approached, and if there is no oil or gas above the oil-bearing rock the sign is favorable. Again the drill may pass through the oil-bearing rocks and show them to be poor and thin.

The logs of wells drilled in a field are valuable as guides to the location of holes in extended parts of the field.

Oil is seldom struck without some warning, as gas shows and light oil shows, which often occur considerable distances above the oil rock.

If there are oil and gas shows with water in thick, porous beds the signs are unfavorable. If these same shows are in thin beds the signs are favorable.

The importance of studying every preliminary piece of evidence, even to the mapping and sketching of the stratigraphy of the country prior to test drilling, cannot be emphasized too emphatically.

The appended table, taken from Cunningham Craig's "Oil Finding," may be of service.

APPLICATION OF GEOLOGY

The oil prospector's attention is easily drawn to the above surface indications, but often the knowledge of geology as described in the previous bulletin, "Oil and Its Geology," will be called into use.

UNFAVORABLE

ALWAYS	USUALLY	SOMETIMES	USUALLY	ALWAYS
Shows of oil with strong gas in their porous beds among impervious strata	Shows of filtered oil with gas	Shows of oil with very little gas	Evidence of estuarine or deltrac conditions	
Light shows of oil in thick porous beds, with water or brine	Evidence of entirely marine conditions	Beds of gypsum or rock salt	Shows of gas below or in a thick argillaceous series	
Water sand below a thick argillaceous series.	Brine	Shows of partially inspissated oil deep down	Shows of partially inspissated oil near the surface	
Hot water with neither oil nor gas	Sulphurated hydrogen accompanied by hot water	Lignites or coals, fossils, resin sulphur or sulphurated hydrogen	Gas in slightly porous strata with pressure increasing downwards	
	Gas shows accompanied by water in porous beds among impervious beds	Ozokerite veins		

FAVORABLE

Again the chief center of interest will be the resemblance of the locality to certain other regions in which oil has been found. A knowledge of the methods of correlating the rock strata and by what they are correlated, is of value.

Chief among the many indications for correlation are:

1. Mineralization;
2. Alteration in character of sediment.
3. Fossil evidence.

From the above evidence the stratigraphical sequence of the strata can be determined. The first important thing is obtaining the thickness of the beds. This will be given by the outcropping distance and the angle of dip. Horizontal outcrops of inclined strata will give a greater thickness than the true thickness.

1. In general the older rocks will be more highly mineralized than the younger ones.

2. The harder and more compact rocks will resist erosion. Valleys tend to follow the softer sections of the country, or valleys may have originally been faults and been inclined by the erosive action of the streams.

Vegetation will often give a clue to change of rock. As for instance, limestones give grassy slopes and steep, barren places. Sandstones grow scrub oak. Shales give slopes with little or no vegetation.

3. Certain strata will give fossils peculiar to that formation, and from the fossils it can be correlated with the other similar or unlike beds of the district. If it contains no fossils, however, the rocks above and below may do so; this will determine the barren strata.

The evidence in the "logs" of water or artesian wells of the district are valuable in determining the succession of rock strata.

EXTENSION OF PROBABLE FIELDS

Many of the productive fields of today are the result of the careful application of geology and the determining of the extension of already existing fields. Since the nearest oil field to the border of the State of Arizona is the San Juan field of Utah, it will be by the careful application of geology, together with the field evidence of the San Juan fields, which will locate oil in the State, if any exists, providing, of course, there are no surface indications. Lately oil has been discovered (found by accident in drilling for water) near Dalton, New Mexico. There were no evidences of oil at the surface, but there are many indications of associated minerals and gases some seventy miles south of Dalton, in Texas; namely, the sulphur and gypsum deposits

of Culberson County, Texas, and the emanation of hydrogen sulphide gas and the occurrence of carbonaceous shale on the surface.

South of the San Juan fields, in Arizona, there are gypsum, salt and sulphur springs. The relation of these to oil has yet to be worked out.

LOCATION OF TEST HOLES

The location of the test holes in drilling for the possible deposits of petroleum is a very important item. Many valuable fields have been condemned as failures because of the first few holes having been put down without careful forethought and application of the evidence which existed and had been collected. Test holes become even more important when funds are available for only one or two holes.

The main factors which govern the placing of the test holes are given here briefly:

1. Location where oil seepages, gas emanations, asphalt residues, structural details and oil rock outcrops are evident.

2. Locations which are made where geological evidence is favorable, as sedimentary strata, anticlinal structure, or conditions which duplicate that structure and which are favorable to the accumulation of oil.

The geological factors which influence both the above are degree of dip of strata, thickness of overlying cover, sudden change of dip due to faulty or secondary foldings.

1. *Well Locations Where Factors Are Evident.* The test well should always be located down the dip from the seepage or outcrop. A location above this would obviously result in a dry hole. When, however, drilling is being done for oil-horizons below the outcrop, this does not apply.

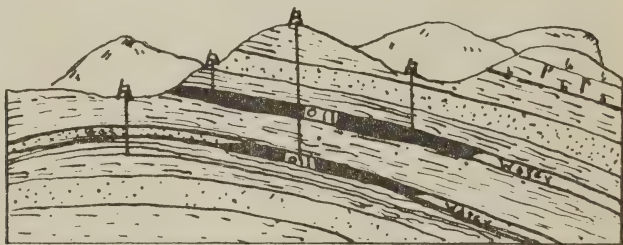


Fig. I

When the outcrops exhibit a symmetrical, anticlinal structure and the axis is determined, the well should be located a short distance

away from the axis towards the flanks. This distance is primarily controlled by the steepness of the dipping flanks. The greater the angle of dip, the nearer the crest the well should be located.

The reason for not locating a well on the crest is the liability of striking gas, either under great pressure or low pressure, which would have to be blown to get the oil. This gas pressure would be of value in forcing the oil to the surface if the oil alone were tapped. Again this gas pressure may be so great as to cause complete loss of the well. Fig. I will serve to illustrate a location on a monocline and symmetrical anticline.

In the case of an symmetrical anticline, the test well should be on



Fig. II

the flank of least dip, as in Fig. II. The possibilities of missing the oil, and the sands yielding little, are great when the well is located on the steeply dipping side.

In the case of domes the test well should be located as for symmetrical anticlines.

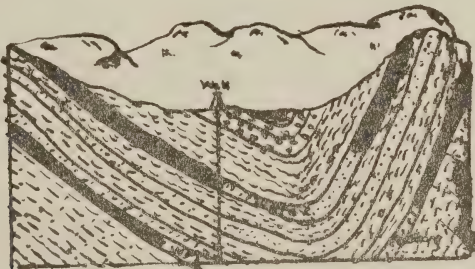


Fig. III

A prospect hole should be drilled so that oil will be tapped at a minimum depth at least cost. A hole of 500-1500 feet will come in these limits.

Topography will greatly influence the depth in many cases as in Figs. I and II. Again the distance of location of the well from the axis of fold or outcrop will influence the depth of the hole. Fig. 2.

Erosion is an influencing factor in determining location, as in the San Juan fields of Utah. Here the oil is located on the flanks of the syncline (Fig. III). In the case of paraffine oil the strata may be barren, due to escape of the oil by evaporation.

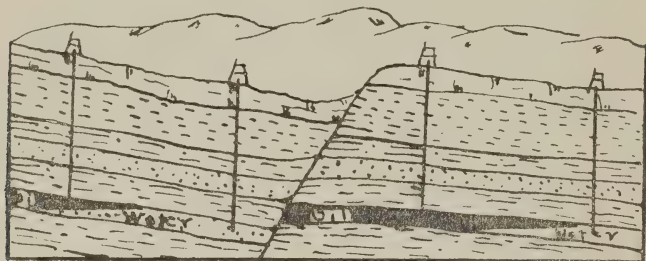


Fig. IV

Faulting has a great influence in the creation of traps or duplicate locations in monoclinical formations (Fig. IV). Again barren spots

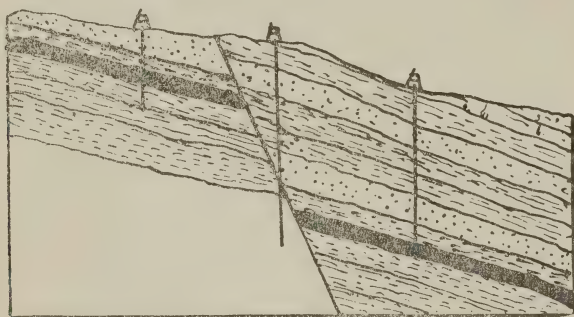


Fig. V

may be created, as in Fig. V. Minor folding will bring about oil localities with barren places between (Fig. VI).

Great care must be taken in the location of wells in faulted areas. If faults are pierced during drilling great difficulty in drilling may be encountered, such as deflection of bore, caving, etc. On the other hand, faults may influence production favorably, as in Fig. V. Again, it may be unfavorable in that it will open the oil-bearing strata to water-bearing strata, producing a condition which could not readily be understood.

Again, a fault may be the cause of the complete loss of the oil in

an oil strata which bears every evidence of being oil-producing. This condition is only liable in faults where the throw has been great. It

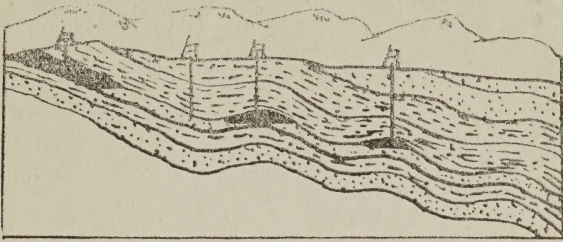


Fig. VI.

is not as likely when the oil is of asphalt base, for the fault is more liable to become sealed.

In fields where the petroleum-bearing rock is fine gravel, faults may materially assist in the production of the field.

In the case of steep anticlinal folds, as in California, the well may have to be located on the crest, and each successive well in the direction of the axis of the fold.

In all locations the determination of the dip is the great factor and every evidence of true dip that is obtainable should be studied. Very frequently the dip as given at the surface is untrue, as all sedimentary rocks are folded, the part at the surface being just a small fraction of a large curve.

The question of accessibility, proximity to water, expense of road-making, etc., are all factors in the location of the well site, but the latter should not detract from the value of that place which has been determined by all evidence as being the most likely place to strike oil.

The water line on oil fields is not always well defined. This depends on the specific gravity of the oil and the porosity of the rocks. An oil whose specific gravity is nearly that of water will not separate from the water so readily, and the line of determination is not abrupt. Many of the California wells have dewatering plants at the wells. In the less porous rock the oil and water have not the facilities to separate.

The water level on the opposite sides of an anticline may vary.

The placing of a well too near the outcrop is not always good, as in the case of an asphalt oil, where the outcrop has been exposed for long periods, the collected heavy matter continues to considerable depth on the dip, and this may materially influence the flow of the well.

2. *Locations Where Geological Evidence Is Favorable.* Locations are frequently made in places where the geological evidence available, together with survey results, indicate that conditions exist

for the accumulation of petroleum. These conditions of accumulation were discussed in detail in the bulletin "Oil and Its Geology." The geological evidence may indicate the extension of new fields and may even indicate probable oil deposits irrespective of the existence of seepages, gas and asphalt outcrops.

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